

FOREST PATHOLOGY:

ITS SIGNIFICANCE IN RELATION TO IRISH FORESTRY PRACTICE.

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(This article is based on data collected during a survey of Irish Woodlands in respect of Insect and Fungous Pests carried out by the writer during the years 1942-45).

Forest Pathology comprises those branches of biological science which deal with disease of forest trees for the purpose of preventing or controlling it.

THE CHIEF CAUSAL AGENTS OF DISEASE.

The majority of diseases in the forest are caused by the activities of living organisms, viz., Animals, of which the most important are Insects and Mites; Fungi; and Bacteria. Insects and Fungi may be regarded as being the most important causal agents of disease.

THE EFFECTS OF DISEASE ON TREES.

During every stage of their growth, trees are liable to be subjected to attack by Insects and/or Fungi. As seeds, they may be attacked by nut-weevils or seed-flies. As seedlings and transplants, they are open to much damage from defoliators and root-feeding insects, and from fungi which cause leaf-cast diseases, girdling of stems, and damping off. From the transplant stage until the end of the sapling stage (i.e., until the canopy closes) is the period in the life of trees during which Insects and Fungi may, and can, cause most serious diseases; this may be accounted for by the fact that young trees are naturally less resistant than older trees, both because they often have difficulty in establishing themselves, and because of their tender tissues. After that period, trees are relatively immune to insect attack, except for occasional attacks by defoliators; trees which have passed the sapling stage seldom die as a result of fungous attack; the fungous diseases on such trees are usually of a chronic nature, and tend to reduce the commercial value of affected trees.

When trees have passed their prime, and growth is less vigorous, they once again become more susceptible to the onslaughts of insects of the bark-beetle and the wood-boring types, and to the fungi of the wood-rotting type. Insects and Fungi may also destroy dead timber and forest products.

Furthermore, the different organs of a tree may be attacked. Roots may be eaten or cut off by Insects or rotted by Fungi.

Stems may be burrowed or have their bark consumed or relieved of its sap by Insects; or, stems may be rotted or have their bark killed by Fungi. Shoots may be cut off or shoots and buds burrowed or galled by Insects, or shoots may die-back as a result of being invaded by Fungi. Leaves are usually more often attacked by Insects or by Fungi than any other organ of a tree, their tissues being either consumed or distorted by Insects; or spotted, distorted, or caused to die-back as a result of being attacked by Fungi.

Trees seldom die as a direct result of insect or fungous attack. It is usually necessary for plants to be weakened by other insects or fungi, or by unfavourable environmental conditions before they succumb to the attacks of major insect or fungous pests.

The ultimate aim of Forest Pathology is to make possible the regulation, in the interest of man, of the activities of Insects and Fungi in forests and forest products. In the control of forest pests, directly protective measures can seldom be applied, because of the excessive cost of such operations, with the result that preventive measures have to be resorted to. This preventive pathology calls for a more profound knowledge of both pests and of forest environment than if direct curative measures could be largely depended upon.

A SHORT CLASSIFICATION OF THE INSECTS AND FUNGI RECORDED AS PESTS OF IRISH WOODLANDS.

INSECTS, which have been found injuring trees in Ireland, are included in the following 5 orders:—

1. Order Lepidoptera (Moths). Many species of Moths are important pests. It is in their larvæ (i.e., caterpillar) feeding stage that Moths assume the role of pests of woodlands.
2. Order Coleoptera (Beetles). This Order includes some of the most serious pests of Irish Woodlands. In their adult stage, in their larval stage, or in both stages, Beetles may cause injury to trees.
3. Order Hemiptera (Sap-sucking Insects). The Sap-suckers injure trees by sucking sap, by disseminating plant diseases, or mechanically, by ovipositing in them. This Order includes Aphids, Adelges, and Scale Insects.
4. Order Hymenoptera. This Order includes Sawflies, Wood-wasps, Seed-flies, and Gall-wasps, all of which, in their larval stage, have been found injuring trees.
5. Order Diptera (Two-Winged Flies). This Order includes March-flies, Crane-flies, and Gall-Midges, whose larvæ feed on trees.

FUNGI, which have been found injuring trees in Ireland, are included in the following 3 Classes:

1. Class Ascomycetes. The fungi of this Class have been found causing canker of stems and branches, die-back of stems,

branches, shoots, or leaves, and leaf-spotting diseases of trees in Ireland.

2. Class Basidiomycetes. This Class includes the Wood-rotting Fungi; the Rusts; and Leaf-cast Disease of Larch.
3. Class Deuteromycetes (Fungi Imperfecti). The fungi of this Class have been found causing canker of stems and branches, and die-back or spotting of leaves or shoots of trees. The fungi of this Class are not Major Pests of trees in Ireland.

Insects and Fungi have been found attacking hardwood and coniferous trees in Ireland. The most widespread and severe attacks of both Insects and Fungi have been recorded on trees less than 20 years old.

Insect Pests of Irish Woodlands.

Our most serious Insect Pests include :—

1. *Rhyacionia buoliana*, Schiff. ;
2. *Prays curtisellus*, Donovan ;
3. *Hylobius abietis*, L. ;
4. *Adelges* spp. ;
5. *Neomyzaphis abietina*, Walker ; and
6. *Chionopsis salicis*, L.

1. *Rhyacionia buoliana*, Schiff. (The Pine-Shoot Tortrix Moth) is one of the most serious pests of Pines in Ireland. It occurs very commonly on Scots Pine and Lodge-pole Pine, fairly commonly on Corsican Pine and Mountain Pine, and occasionally in *Pinus insignis* and Austrian Pine. It has also been noted on *Pinus rigida*, Banks Pine, and Maritime Pine. The most severe attacks have almost invariably been recorded on Scots Pine.

Trees less than two years planted in the forest are not attacked. Trees planted between 2-5 years in the forest are usually attacked in their terminal leading bud. Leading and lateral buds of trees planted between 5-25 years in the forest may be attacked; the attack is usually confined to the lateral buds of trees planted longer than 25 years in the forest.

Areas of Pine pure are usually more severely attacked than areas in which Pine is mixed with other species. In cases of very severe attacks, practically all terminal lateral buds in the upper half of affected trees, including the terminal leading bud, may be attacked.

The fact that leading buds of Pine are so frequently subjected to attack by *R. buoliana*, especially in cases of severe attack, precludes the employment of efficient control. One of the subtending lateral shoots takes the place of the leading shoot whose terminal bud has been burrowed by *R. buoliana*, but such substitute leaders may subsequently have their terminal buds burrowed. In areas in which the attack is common and severe, this repeated burrowing as the terminal buds of substitute leaders stunts growth so severely of to preclude the production of any but inferior grade timber.

2. *Prays curtisellus*, *Donovan* (The Ash Bud Moth) is the most serious pest of Ash in Ireland. Its caterpillars attack and burrow the buds of Ash. Ash of all ages may be attacked, but the attack is most severe on Ash less than 20 years old, on which leading and lateral buds may be burrowed. On Ash 20 years old and older the attack is usually confined to buds on lateral shoots.

On account of the death of the terminal bud on any shoot, the two subtending lateral buds are stimulated into growth, resulting in a forked type of growth. When terminal leading buds are burrowed, the resulting main stems of Ash are forked. Most of the forked pole-stage and older Ash throughout the country result from attacks of *P. Curtisellus* early on in their life.

The attack of *P. curtisellus* is widespread in the country. Usually it is not as common or as severe on artificially-regenerated Ash as it is on Ash naturally regenerated. This may in part be accounted for by the fact that artificially-regenerated Ash suffers less (on account of being spaced well apart) from competition from its neighbours than naturally-regenerated plants (which are usually crowded together on an area).

As the terminal leading buds are so frequently burrowed by *Prays curtisellus*, no efficient control measures may be applied.

3. *Hylobius abietis*, *L.* (The Large Pine Weevil) is the most important Coleopterous pest of Irish Woodlands. In its adult stage, *H. abietis* does most damage. The adults first remove and discard the coarse outer bark of its host plants, and then consume the soft bark and cambial layer.

Attacks of Large Pine Weevil are most common on Scots Pine, fairly common on Norway Spruce, occasional on Lodge-pole Pine and Sitka Spruce, and are rarely recorded on Corsican Pine, European and Japanese Larches, and Common Silver Fir.

Injury due to attack of the Large Pine Weevil occurs on stems and branches of young trees, being usually most severe on the lower part of the main stem. Trees less than 8 years planted in the wood are commonly attacked in this manner, but the attack is most common and most severe on trees during the first three years after they have been planted out in the wood. Trees over 8 years planted in the wood are usually attacked on branches only, but may be attacked on the main stem in areas where growth is stunted. In many woods the attack is confined to those young plants planted in the neighbourhood of isolated trees or patches of trees of old Scots Pine.

H. abietis usually breeds in dead Scots Pine, but it has also been recorded breeding in dead Lodge-pole Pine, Corsican Pine, and Norway Spruce. Breeding activity has occurred on young trees (7-20 years planted-out in the wood) when they have been about one year dead. Breeding activity has usually taken place on stumps of old Scots Pine, when the stumps were between one and two years old.

The percentage of young trees which die, as a result of being attacked by *H. abietis* is usually very small. Sometimes, however, when trees have been severely attacked for three consecutive years, the number of trees fatally injured is significant. Trees, which have been consistently attacked in the young stages for a number of years are stunted, and will probably never reach saw-timber size. The combined attacks of *H. abietis*, *Rhyacionia buoliana*, and *Myelophilus piniperda* (The Pine Shoot Beetle) on old Pines result in a distortion of their crowns. A reduction in the quantity of seed which old Scots Pine could produce may be attributed to the pruning action of those pests in the crowns of seed-producing trees.

As it is almost impossible to exterminate any pest from a country, the next best method of procedure is to confine it within such narrow limits that its attacks will be of small consequence. In the case of *H. abietis*, this latter result may be most easily achieved by destroying its breeding-grounds. This involves the removal of dead Pines and logging waste and the barking of fresh stumps of old Scots Pine in woods being cut over, before replanting such areas, and the trapping of adults of *H. abietis* in areas in which they are attacking young plants.

4. *Adelges spp. on Spruce, Larch, Pine, Silver Fir, and Douglas Fir.*

(i) *Adelges abietis* Ratz. The primary host of this species is Spruce, on which it produces globular galls. Those galls occur at the base of the spruce shoots, generally encircling only half the shoots, which normally grow beyond them. The galls usually occur on lateral shoots; occasionally they occur on leaders. The amount of injury caused to Spruce by *A. abietis* is usually of small consequence. The fact that galls have been found on leaders of spruce in a number of areas lends a new importance to *A. abietis* on Spruce. An epidemic of this type of damage, although it is highly improbable that such will occur, would give a very severe check to Spruce-growing in Ireland.

(ii) *Adelges strobilobius*, Ralt. The primary host of this species is Spruce, on the shoots of which it produces terminal globular galls, which kill the shoots on which they occur. They occur most commonly on poles and older Spruce, being rarely present on trees less than 20 years planted; Spruce less than 10 years planted have not been attacked. The pruning effect of *A. strobilobius* on Spruce limits the quantity of food which trees can take, thus reducing the rate of growth. As the most severe attacks occur on trees which are almost mature, and thus putting on quality increment, this reduction in the rate of growth is highly significant.

Both *A. strobilobius* and *A. abietis* occur on Norway Spruce, Sitka Spruce, and *Picea morinda*, and occur commonly in Ireland.

The secondary host of both *A. abietis* and of *A. strobilobius* is Larch. The Adelgid lice occur on the needles of Larch in the case

of *A. abietis*, and on the shoots and needles of Larch in the case of *A. strobilobius*. They occur on Larch throughout Ireland, and are usually present in such abundance that the drain of sap from infested trees must cause a significant retardation of growth. Although they may not kill trees, they may be the cause of serious ill-health to the infested trees by allowing spores of *Dasyscypha calycina* (Larch Canker) to enter shoots and branches through the pores made by their sucking mouth-parts.

(iii) *Adelges pini*, Koch. The presence of this species on Pine is indicated by the fact that white woolly secretions (which cover the Adelgid lice) occur on stems, branches, or shoots of trees. It occurs on Pine throughout Ireland. It is most common and severe on Scots Pine, fairly common on Corsican Pine, and has been noted on Weymouth and Mountain Pines, and *Pinus insignis*. On Lodge-pole Pine it has been found only on nursery stock and on plants recently planted in the forest.

The disease is most common and severe on nursery stock and on trees less than 15 years planted out in the forest. It is most severe in areas where exposure is severe. The withdrawal of sap from the shoots results in the die-back of the needles, which are then usually attached by *Lophodermium pinastri*. The holes made in the bark by *A. pini* give spores of *Dasyscypha* spp. (canker) access to the stems and branches of Pine. When current year's shoots are severely attacked in early summer, the needles of those shoots are foreshortened, and of a sickly yellow colour. This curtailment of the carbon-assimilating surface of plants results in a reduction in the amount of food available for the plants, and hence, stunts the growth of infested plants.

(iv) *Adelges nüsslini*, Börner. White woolly secretions (covering the Adelgid lice) on shoots and branches (and in summer, on needles) of Silver Fir, indicate the presence of *A. nüsslini*. The disease is very common on Silver Fir throughout Ireland, occurring on *Abies pectinata*, *Abies Nordmanniana*, and *Abies cephalonica*. It has also been recorded on *Abies concolor*, *A. lasiocarpa*, *A. grandis*, and *A. nobilis*.

When the attack is severe, the needles become mottled green and yellowish-green on their upper surface; they are drawn backwards and lose their rigidity on account of the drain of sap from their undersurface. The drain of sap from shoots and needles causes them to die-back. In the case of *Abies pectinata*, trees of all ages are subject to infection. The most severe attacks occur on trees 40 years old and younger. The attack is generally of a mild nature on old trees, shoots only being affected.

[The primary host of *Adelges pini* and of *Adelges nüsslini* is Oriental Spruce, on which, however, I have not noted those diseases.]

The secondary hosts of *A. pini* and of *A. nüsslini* are Pine and Silver Fir, respectively).

(v) *Adelges picea*, Börner. The secondary hosts of *A. picea* are *Abies* spp. It has no primary host. Its presence on Silver Firs is indicated by the presence of numerous white woolly secretions (covering the Adelgid lice, which suck the sap) on the bark of the main stem. It has been found on trees of 30 years and older of *Abies pectinata*, *A. Nordmanniana*, *A. cephalonica*, and *A. concolor*.

A. picea also takes the form of spindle-shaped galls on branches of poles and older *Abies pectinata*. This type of injury is of small consequence on Silver Fir in Ireland.

(vi) *Adelges cooleyi*, Gillettee. The primary host of *A. cooleyi* in Ireland is Sitka Spruce, on the shoots of which it produces median, elongate galls, which completely encircle the shoots on which they occur. The galls occur on lateral shoots, but have been recorded on leading shoots of Sitka Spruce in two woods. Trees, 6 years and older, in the forest are attacked, but the most severe attacks occur on trees from 12-15 years planted. The gall-stage of *A. cooleyi* on Sitka Spruce is usually of little consequence; however, the fact that leaders have been galled is worthy of note, as an expansion of this type of damage would seriously injure the value of Sitka Spruce in Irish plantations.

The secondary host of *A. cooleyi* is Douglas Fir, on which the damage caused is of a much more serious nature. Its presence on Douglas Fir is indicated by the presence of white woolly secretions (which cover the Adelgid lice) and/or minute wingless lice on the undersurface of the needles. The attack occurs on Douglas Fir, of all ages except on plants which have been less than 5 years planted in the forest; it is generally very severe on trees 9 years and older in the forest. The withdrawal of sap from the needles causes them to turn brown and die-back. In cases of severe attack, trees lose all but the current year's needles, so that they have to depend on those needles, which may themselves be also attacked, for the carrying out of their vital processes. This leads to a serious retardation of growth, which is especially noticeable on trees on exposed hill-sides.

5. *Neomyzaphis abietina*, Walker (The Green Spruce-Aphis) is a small green aphid which sucks sap from the underside, usually, of needles of Spruce throughout Ireland. This pest attacks Spruce of all ages, both in the nursery and in the forest. It is more severe on Sitka Spruce than on Norway Spruce.

Where the attack is mild or fairly severe in any area, occasional plants, usually the more vigorous ones, may be severely attacked. When attacked, needles at first turn yellow, later to brown, and finally die and fall off. Where attack is severe, buds of Spruce remain dormant until early summer.

The attack of *N. abietina* is least severe in areas suitable for the growth of Spruce. It is most severe on Spruce (i) planted in

shade or partial shade of older trees, (ii) planted in frost hollows, and (iii) planted in very exposed areas. The fact that Spruce is seldom completely defoliated as a result of being attacked by *N. abietina* ensures that its vital functions are not completely arrested; it will survive unless attacked by some other agency of disease. Stunted plants are the aftermath of severe attacks of *N. abietina*.

6. *Chionapsis salicis*, L. (The Willow and Poplar Scale) is a small louse which, under the protection of a small white scale, sucks sap from the bark of stems, branches, or shoots of Ash, Willow, and Alder throughout Ireland. It has also been noted on Sallow, White American Ash, *Fraxinus oregona* and *F. pubescens*.

As the period during which *C. salicis* is developing corresponds with the period during which the host trees are in the active growth stage, it is only natural that the drain of sap causes serious injury to the hosts. The attack of *C. salicis* on Ash is most significant. As a result of severe attacks, the wood of Ash becomes fairly brittle, and snaps more easily under strain than Ash which has not been attacked. The scales of *C. salicis* are most numerous on stems of Ash from 3"-8" in diameter at breast height. Middle-aged and old Ash are not attacked on the main stem, but smooth-barked branches of those trees may be affected. This pest is most severe on Ash under over-crowded conditions, and also in areas where drainage conditions are bad.

Other species of Insects, which (although widespread in occurrence in Ireland, but whose attacks so far in most areas have not been of economic importance) under favourable conditions for their reproduction in abundance, may yet be classed as Major Pests of Irish Woodlands under an expanding system of Forestry here, include :

1. Bark Beetles ;
2. *Diprion pini*, L. ;
3. *Strophosomus melanogrammus*, F. ;
4. *Otiorrhynchus picipes*, F. ;
5. *Orchestes fagi*, L. ; and
6. *Phyllobius viridiaeris*, L.

1. *Bark Beetles* pass through all stages of their life-cycle under the bark or in the wood of trees. In Ireland all our Bark-Beetles use dead trees, felled trees, or dead branches of living trees as breeding-ground. The adults and larvæ of Bark-Beetles make tube-like galleries between the bark and the wood, the characteristics of which indicate the species of Bark-Beetle that made them. The Bark-Beetles occurring in Ireland include : *Myelophilus piniperda*, Eich. (The Pine-Shoot Beetle) ; *Hylastes ater*, Payk. ; *H. opacus*, Er. ; *Pityophthorus ramulorum*, Perris ; and *Pityogenes bidentatus*, Herbst., all of which occur on *Pinus* spp ; *Hylastes cunicularis*, Er. on Norway Spruce ; *Hylurgops palliatus*, Gyll. on Norway Spruce

and European Larch; *Tomicus laricis*, F. on European Larch; *Dryocetes villosus*, F. on Oak; *Hylesinus crenatus*, F., and *H. fraxini*, Panz. on Ash; *Trypodendron domesticum*, L. on Beech; and *Eccoptogaster scolytus*, F. on Elm. *Myleophilus piniperda*, Eich. is our most important Bark-Beetle.

Most of our Bark-Beetles are secondary enemies of trees, their attacks being associated with adverse influences reacting on plantations. Our immunity from extensive outbreaks is possibly due to the limited extent of our forests.

2. *Diprion pini*, L. (The Pine Sawfly). The caterpillars of this species, feeding in companies, eat needles of *Pinus* spp. back to the needle-sheaths. They have been found attacking Scots and Lodgepole Pines fairly commonly throughout Ireland; occasionally they have been found on Corsican and Mountain Pines, and rarely on *Pinus insignis* and Maritime Pine. The most severe attacks have been recorded on Pine 4-12 years planted in the forest. As a rule, throughout Ireland, less than 3 % of the Pine in any area are either completely or partially defoliated. Severe attacks have been noted in a limited number of areas. The reduction in foliage due to defoliation naturally retards growth to a certain extent.

3. *Strophosomus melanogrammus*, Fo. is a small greyish-black weevil which eats bits out of leaves of conifers, but, on hardwoods, skeletonises small isolated patches of each leaf it attacks. It is widespread in occurrence in Ireland, occurring very commonly on Beech, *Tsuga* spp., Birch, Spruce, Hazel, and Mountain Ash; occasionally on *Pinus* spp., Douglas Fir, *Thuja plicata*, *Cupressus* spp., Oak, and Willow, and rarely on Elm. The most severe attacks occur on trees less than 12 years old, especially when they have been planted in partial shade. On older trees, the attack, though widespread, is usually of a mild nature. Shoots of Spruce, and of Birch may be ringed at their base by adults of *S. melanogrammus*.

4. *Otiorrhynchus picipes*, F. (The Clay-coloured Weevil), is a small grey-brownish-black weevil which eats bits out of leaves of conifers, but, on hardwoods, usually eats leaves back to the main vein. It is widespread in occurrence in Ireland, being very common on *Abies* spp., *Thuja plicata*, *Tsuga* spp., and Mountain Ash; fairly common on Douglas Fir, Beech, Birch, and Hazel; occasional on Willow, Oak, *Cupressus Lawsoniana*, and Scots Pine, and is rare on other Pines, and on Ash, Larch, Hornbeam, Sycamore, Lime, Horsechestnut, Yew, Elm and *C. macrocarpa*.

The attack is most severe on trees less than 12 years old, especially when they have been used for underplanting in older wood, and is usually mild on older trees. Adults of *O. picipes* also ring shoots of species of *Abies* in pole stage.

As severe attacks of *Strophosomus melanogrammus* and of *Otiorrhynchus picipes* have been recorded on the continent of Europe, it is quite possible that such should occur here in the future.

5. *Orchestes fagi*, L. (The Beech Leaf-Miner). The larvæ of this weevil mines in the developing leaves of Beech, and the adult weevils cause shot-holing of the leaves of Beech. The adults occasionally occur on leaves of Ash, Birch, Sycamore, and Elm, portions of whose leaves they skeletonise. *O. fagi* attacks Beech of all ages, but is usually most abundant on older trees. The attack on nursery stock is generally of a very mild nature. Although the health of trees, even when their leaves bear numerous larval mines and adults' shot-holes of *O. fagi*, does not seem to be seriously impaired, their food-supply must be seriously curtailed as a result of the injury to their foliage, which occurs so early in the growing season.

6. *Phyllobius viridiaeris*, L. is a small bright-green weevil. It eats leaf-tissues of beech and oak plants, being usually found on plants less than 8 years old. The most severe attacks have been recorded on Beech, which has been almost completely defoliated in many woods. An increase in the population of *P. viridiaeris* would form a definite threat to the artificial regeneration of our woods with Beech and Oak.

Most other species of Insects, which have been recorded in Ireland are not of much economic importance, either because of the limited nature of their occurrence, or due to the fact that their attacks are confined to accessory species of trees.

Fungous Pests of Irish Woodlands.

Our most serious Fungous pests include :—

1. *Armillaria mellea* (Vahl.) Fr. ;
2. *Fomes annosus*, Fr. ;
3. *Dasyscypha calycina*, Fuckel ; and
4. *Nectria ditissima*, Tul.

1. *Armillaria mellea* (Vahl.) Fr. (Honey Fungus) causes the most serious root-rot of broadleaved and coniferous trees in Ireland ; it has also been found on certain shrubs. The fructifications of the fungus are toadstools, and occur in clumps at or near the base of dead trees or stumps, which had been killed by attack of *A. mellea*. They are borne on rhizomorphs. Two types of rhizomorphs have been noted, (i) round black ones, which occur in the soil, and cause infection of fresh host trees by entering through wounds on roots, and (ii) black flattened ones, which occur between the bark and the wood of trees in the advanced stages of infection.

The development of the disease is slow in the case of older trees, and may take years in the case of broadleaved trees. Young trees, however, may be killed in less than a year after infection has begun. The needles of young conifers, which have been attacked, at first turn to sickly yellow, later to brown or red, and finally die. Under the bark at the base of recently killed trees a thick white web of mycelium occurs ; when the trees have been dead for some time,

this weft segregates into flattened strands (the subcortical rhizomorphs).

That the disease occurs on patches of plants, which gradually enlarge, indicates that the cylindrical rhizomorphs in the soil play an important part in spreading infection. Those rhizomorphs, which form a network in the soil, emanate from trees which have succumbed to attack of *A. mellea*, and attack all susceptible trees in their vicinity. Once in a susceptible host the fungus produces a dry rot in it. This rotted dried wood is permeated with black zone lines. The rotted wood eventually disintegrates into cubical fragments. All infected trees eventually die due to complete girdling at the base.

The disease is widespread in Ireland. It has been found very commonly on Beech, Oak, Ash, Scots Pine, Sitka Spruce, Japanese Larch, and Norway Spruce; fairly commonly on Birch, Elm, Sycamore, *Abies pectinata*, Douglas Fir, European Larch, *Cupressus Lawsoniana*, and *Cupressus macrocarpa*; and rarely on Lime, Hazel, Spanish Chestnut, Willow, Poplar, Alder, *Abies grandis*, Corsican Pine, *Pinus insignis*, *Pinus contorta*, *Tsuga* spp., *Wellingtonia gigantea*, and *Sequoia sempervirens*. It has also been recorded on *Aurucaria*, *Eucalyptus*, the golden form of *Cupresses macrocarpa*, Holly, and *Rhododendron*. In the case of Conifers, trees of all ages, except those less than one year planted in the wood, have been found attacked. In the case of broadleaved trees, trees of all ages, except those less than 8 years old, have been found attacked.

In most woods examined in Ireland, less than 3 % of the trees have been found infected by *A. mellea*; rarely more than 10 % of all the susceptible species of trees in any area are involved in the attack, and only in 10 woods have more than 25 % of the trees been infected.

Under our conditions, the disease is not of a serious nature in fresh plantations. It has been most severe in replanted areas, particularly on young coniferous plantations on old hardwood sites. In cases of isolated outbreaks, such as are usually found in the different forest properties in this country, the Trench System, as originated by Hartig, would be useful to stem the attack.

2. *Fomes annosus*, Fr. (Heart-Rot of Conifers) is the most important cause of butt rot of Conifers in Ireland. The fungus enters through the roots of its host species, and passes into the heartwood, on which it produces a rot. Trees less than 19 years planted in the wood, when attacked by *Fomes annosus*, succumb to the attack. On trees older than this, the attack of *F. annosus* causes a rot in the heartwood; eventually the rotted heartwood disintegrates, resulting in pipeness of the butt of affected trees; such trees are not usually killed, but may be suppressed by their unaffected neighbours. Zone lines are present in the rotted wood; and beneath the bark of dead trees, a very thin sheath of white mycelium has been noted.

The fructifications of the fungus (brown, perennial, bracket-shaped structures) occur in concentric rings, and are found at the base of dead trees or of stumps of trees which had been infected prior to being felled.

F. annosus is widespread in Ireland. It has been found most commonly on European Larch, Scots Pine, Japanese Larch, Douglas Fir, Sitka Spruce, and Norway Spruce; occasionally on *Abies pectinata*; and rarely on *Thuja plicata*, and Corsican Pine. It has also been recorded on *Abies grandis*, *Isuga* spp., and Lodgepole Pine. In most of the areas in which *F. annosus* was recorded, it had attacked less than 3 % of the host species of trees; rarely were more than 10 % of the host trees in any area attacked, and only in 2 areas were more than 25 % of the host trees infected.

3. *Dasyscypha calycina*, Fuckel (Larch Canker) causes cankers of stems or branches of Larch. The canker appears as a depression on the bark of the stem or branch, this deformation being generally accentuated by increased growth in thickness on the other side of the stem and on the sides of the canker. The cankers occur on the stems and branches of Larch of all ages except trees less than 1½ years planted in the forest. On trees less than 15 years planted in the forest the canker occurs at the lower portion, or at the base, of the stem, usually one canker per stem, and the portion of the stem apical to the canker dies-back; trees older than this seldom die as a result of attack. Trees in the pole-stage are most commonly attacked, and may bear 1-20 cankers per stem. On older trees, the cankers are usually found on branches, which usually die-back as a result of infection. Branches of saplings and poles of Larch may also be cankered and die-back. Young trees, during the first six years after they have been planted in the woods, may be attacked and killed by *D. calycina*, no cankers being formed in such cases, but the surface of the bark of such trees is covered with apothecia (i.e., the fructifications) of the fungus. Apothecia are also numerous on dead branches of saplings and older Larch, and on bark on the edges of canker.

D. calycina is widespread on European Larch in Ireland, the cankers and/or the fructifications being present to a greater or lesser degree in all plantations of this species. Japanese Larch is also attacked, but usually to a lesser extent than E. Larch. European Larch of Scottish, Irish, and Silesian origin, and West American Larch are also susceptible to infection by *D. calycina*.

It is the most serious disease on Larch in this country. It is most severe on Larch (i) in very exposed sites, (ii) in sheltered valleys, especially where proper silvicultural treatment has not been given soon enough, and (iii) on unhealthy trees. Larch in mixture with other species of trees appears to be just as susceptible to infection as pure plantations of Larch. Larch attacked by *Adelges* spp. is very susceptible to infection by *D. calycina*.

Any measures which promote the production of a vigorous healthy crop of Larch will tend to reduce the incidence of Larch Canker.

4. *Nectria ditissima*, Tul. Cankers caused by this fungus are found very commonly on Beech, and occasionally on Ash, throughout Ireland. The cankers are rarely produced on trees less than 8 years old.

The most usual types of injury resulting on Beech and Ash from attack of *N. ditissima* include :

- (i) Cankers on branches of poles, middle-aged, and old trees, usually not causing die-back of such branches.
- (ii) Cankers on stems and branches of saplings, poles, middle-aged, and old trees which, as a rule, do not cause die-back of such stems and branches.

[Types (i) and (ii) are widespread in occurrence on Beech in Ireland ; but, in the case of Ash, usually less than 3 % of the trees in any area are involved in the attack].

- (iii) Die-back of branches and shoots of saplings and older trees to the point on the branches at which the cankers occur. (This type of injury has usually been found on Beech, but is present to such a limited degree on Beech in any area as to be of small consequence).
- (iv) Canker at base of stem of young Beech and Ash, resulting in the death of such trees. (This type of injury has been recorded on less than 3 % of the trees in a limited number of forests).
- (v) Canker on stems of young trees, causing the death of the portion of the stem apical to the canker. (This type of injury has been recorded on less than 3 % of the saplings of Beech and Ash in a number of widely-distributed areas in Ireland).

Cankers on stems and branches of Beech and Ash tend to distort affected trees, and to reduce the quality of the timber produced so much that it is suitable only for firewood.

Other species of Fungi, which may yet be classed as Major Pests of Woodlands here, include :

1. *Fomes applanatus*, Pers. ;
2. *Dasyscypha* spp. on Pines ;
3. *Microsphaera quercina* (Schw) Burrill ;
4. *Meria laricis*, Vuill. ; and
5. Rusts of Pines and of Larch.

1. *Fomes applanatus*, Pers. (White Mottled Rot) causes a butt-rot, and at times a trunk-rot, of broad-leaved trees. The disease occurs on trees which are mature or almost so. The heartwood of infected trees becomes soft and spongy, pale brown in colour, and woven through it occur black strands of mycelium (reminiscent of the rhizomorphs of *A. mellea*). In the case of most of the infected trees noted, the rotted wood had disintegrated, leaving the centre of the bole hollow.

The fructifications of *F. applanatus* are hard, woody, perennial structures, which are usually bracket-shaped, but are sometimes unguulate in shape. They are usually attached at or near the base of infected trees in the advanced stages of decay; they are also common on dead trees and on stumps.

The disease occurs commonly in Ireland. It has been recorded most commonly on Beech, fairly commonly on Ash and Oak, occasionally on Elm, Sycamore and Birch, and has been recorded on Spanish Chestnut, Lime, Walnut, Horse-chestnut, and Poplar. It has also been recorded on old *Abies pectinata* in two woods. In most areas in which the disease has been recorded, less than 3 % of possible hosts were infected; rarely more than 10 % of the possible host trees in any wood are involved in the attack.

2. *Dasyscypha spp. on Pines*. Cankers, similar to those caused by *D. calycina* on Larch, are caused on Pines by *Dasyscypha spp.* Those cankers occur on stems of saplings and poles of *Pinus spp.*, and on branches of saplings and older Pines. They have been found most commonly on Scots Pine, but also occur on Corsican, Lodgepole, and Mountain Pines.

Pine canker has been found in a number of widely-distributed areas in Ireland. Except in a limited number of areas, less than 3 % of the Pine in any area were infected by *Dasyscypha spp.* An expansion of this type of injury on Pines in this country would have serious results.

3. *Microsphæra quercina* (Schw.) Burrill (Powdery Mildew of Oak). This fungus, appearing on leaves of Oak as a whitish mould, kills such leaves.

This disease is widespread in occurrence on Oak in Ireland. It is generally particularly severe on Oak less than 8 years old, especially on suckers of Oak, and on seedlings and transplants of Oak in the nursery. Saplings of Oak are occasionally severely attacked. On poles and older Oak, *M. quercina* is usually present on leaves on epicormic branches, and on leaves on the current year's shoots on the lower branches of the crowns.

One of the consequences of severe attack of *M. quercina* is the death of the current year's shoots of Oak. Such shoots, when they have dried out, are shrunken, brown in colour, and are brittle.

M. quercina has also been recorded on Beech in a limited number of woods.

4. *Meria laricis*, Vuill. (Leaf-cast Disease of Larch) causes browning and death of needles of European Larch. Needles on the apical portion of shoots do not become infected, and so, contrast with the dead brown needles lower down on the same shoots. Affected needles usually fall early in Autumn.

M. laricis has been noted fairly commonly on European Larch in Ireland. It has been found most commonly on nursery stock and

on plants less than 10 years planted in the wood. Needles on lower branches of host trees have, as a general rule, been affected.

5. *Rusts of Pine and Larch.* The most important Rusts on those trees include :

(i) *Coleosporium senecionis.* The primary host of this rust is groundsel. The secondary hosts are species of the 2-needled Pines ; on Pine the disease is known as Peridermium pini rust. The fungus causes delicate white blisters (called æcidia) on Pine needles. Those æcidia enclose the spores, which, when liberated, cause infection on groundsel. When the disease has passed through its cycle on groundsel, the spores liberated from pustules on the groundsel leaves re-infect needles of Pine. Pine needles, which bear æcidia, die.

This disease is widespread in occurrence in Ireland. It has generally been recorded on Scots Pine, but has also been recorded on Corsican Pine in a number of woods. The disease has been found only on saplings and younger trees in the forest, and on nursery stock.

(ii) *Melampsoridium betulinum, Kleb.* (= *Peridermium laricis*). The primary host of this rust is Birch, the leaves of which it causes to die-back.

On needles of European Larch, the fungus produces delicate white pustules (the æcidia) in which the orange spores are borne. Those spores, when liberated, infect leaves of Birch ; after running its course in the Birch, the spores liberated from pustules on the Birch re-infect needles of Larch. Infected needles of Larch turn brown and die. On Birch, the disease may be seen throughout the growing season, but on European Larch, the disease has been identified by me with certainty only during the latter half of April and during the summer months. So far, the disease has not been of much consequence on European Larch, except in a few isolated cases.

Most other species of Fungi, which have been recorded in Ireland, are not of much economic importance, either because of the limited nature of their occurrence, or due to the fact that their attacks have been confined to accessory species of trees.

Ireland's Position with regard to Forest Pests.

The actual amount of injury caused to Irish Forests as a result of the onslaughts of Insects and Fungi is very small as compared with the ravishes of those pests in woodlands in other countries. This is in part due to the limited extent of our woodland area, and, also, due to the fact that many of the Insects and Fungi which cause serious injury to woodlands in other countries have not, so far, been recorded in this country. Many of those foreign Insect and Fungous Pests may, with the passage of time, be introduced into this country through the medium of imported timber supplies.

Some of those pests may be present here, although their presence is not, so far, a recorded fact.

With the progressive increase in our forest area, many Insects and Fungi, which at present are regarded as of minor importance, may assume the role of major pests.

Proper silvicultural treatment of woodlands from their inception onwards would serve, better than any other treatment, to reduce the amount of injury, resulting from attacks of Insects and Fungi, to a minimum.
